



Grid Modernization Initiative Crosscut Discussion-EAC

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Grid Modernization Vision

*The future grid will solve the challenges of seamlessly integrating conventional and renewable sources, storage, and central and distributed generation. It will provide a critical platform for U.S. prosperity, competitiveness, and innovation in a global clean energy economy. It will deliver **reliable, affordable, secure, resilient, and clean** electricity to consumers where they want it, when they want it, how they want it.*

Security and Reliability for the Nation

- Extreme weather
- Cyber threats
- Physical attacks
- Natural disasters
- Fuel and supply diversity
- Aging infrastructure

Economic Growth and Innovation

- New energy products and services
- Efficient markets
- Reduce barriers for innovation
- Clean energy jobs
- Access to reliable, affordable electricity

Environmental Sustainability

- 80% clean electricity by 2035
- State RPS and EEPS mandates
- Climate adaptation and resilience



DOE's Grid Modernization Initiative Goal

Accelerate the modernization of the North American Grid through 2025, by

- Core R&D and proof of concept activities that integrate technology innovation
- Technical assistance and institutional support
- Regional demonstrations at multiple scales to demonstrate marketability
- Partnerships and FOAs with industry and the research community
- Technology transfer to industry



GMI's Integrated Technical Thrusts

Technology Innovation

Institutional Support

- Evaluate regulatory and policy options, technology value, and implications of various grid operations models

Design and Planning Tools

- Improve planning and decision tools and make them accessible to all stakeholders

System Operations, Power Flow, and Control

- Design and implement a new grid architecture that coordinates and controls millions of devices and integrates with energy management systems

Sensing and Measurements

- Advance low-cost sensors, analytics, and visualizations that enable 100% observability

Devices and Integrated System Testing

- Develop advanced, flexible, and interoperable grid control and integration devices and validate integrated systems

Security and Resilience

- Develop advanced security (cyber and physical) solutions and real-time incident response capabilities



GMI's Technical Thrusts

Institutional Support



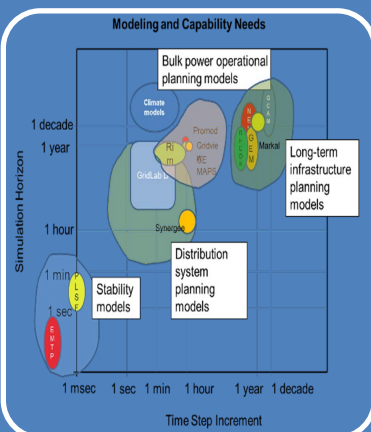
•High Level Outcomes

- Enhanced ability for regional, state, and tribal policymakers to make decisions on existing and emerging policy, technology, regulatory, and market issues in the electricity sector and for PUCs to assess proposals for changes to existing regulation and new business models
- Reduced risks and better investment decisions regarding integration of emerging technologies, valuation of technologies, and opportunities for consumers to participate in the energy market

•Selected Major Technical Outcomes

- Valuation of DER - New methods for valuation of DER technologies and services that are clearly understood by stakeholders and enable informed decisions on grid investments
- Distribution Planning - Technical assistance to at least 10 states improving their ability to review utility distribution system plans, including DER, and advanced grid components and systems

Design and Planning Tools



•High Level Outcomes

- New tools that identify cost-effective approaches for capital and technology investments, operational approaches, and market designs to meet operational and economic performance objectives
- Engineering modeling tools that improve grid reliability and resilience
- New algorithms and modeling tools that reduce the time for solving complex grid modeling problems and substantially extend the complexity and volume of scenarios analyzed

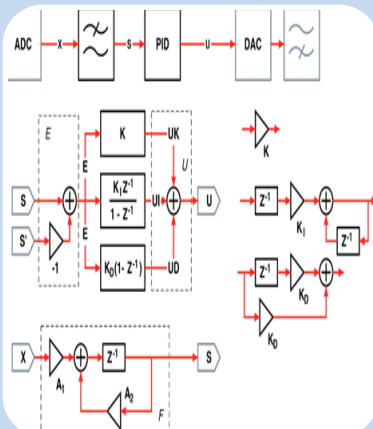
•Selected Major Technology Outcomes

- Stochastic Tools - Improve scaling to model electric and gas system inter-dependencies from 1,000 to 60,000 electric and 100 to 1,000 gas nodes
- Reliability and Resilience - Improve performance of contingency analysis tools by 500x to capture extreme events; enable automated analysis of cascading events



GMI's Technical Thrusts (con't)

System Operations, Power Flow, and Control



•High Level Outcomes

- Improved grid architecture to reduce hindrances to improving grid flexibility and resilience and control theory to accommodate large numbers of interconnected distributed and semi-autonomous systems
- Grid control technologies that will allow the system to be operated with less reserve margin, dramatically enhancing the economic efficiency of the overall system
- Performance and cost improvements in high voltage power electronics devices enabling improved controllability and greater flexibility of the electrical grid

•Selected Major Technology Outcomes

- Analytics and Computation – Enhanced decision support to operators in control rooms through pinpoint visualization and cognitive technologies
- Wide-area Control - Strategies that will improve reliability, resilience, and asset utilization

Sensing and Measurements



•High Level Outcomes

- Reductions in the cost and implementation of sensors across transmission, distribution, and end-user building systems
- Enhanced accuracy of sensor and measurement devices to minimize uncertainty
- Improved models, frameworks, and software to enhance interoperability, reliability, and security of a unified grid communications network

•Selected Major Technology Outcomes

- Real-time Data Management – Tools and analytics for managing ultra-high velocities and volumes of grid data from T&D systems and the ability to identify and compensate for inaccuracies and errors
- Reliability and Resilience - Development of low cost, multi-purpose sensors (under \$100 per sensor or two year payback) that operate in normal and off-normal operations



GMI's Technical Thrusts (con't)

Devices and Integrated Systems Testing



•High Level Outcomes

- Cost effective microgrids and energy storage applications to improve customer reliability
- Interconnection & interoperability standards that streamline processes & reduce distributed energy integration costs
- Smart interfaces that provide reserves to bulk power systems and reduce interconnection costs

•Selected Major Technology Outputs

- Energy Storage – Decrease the system costs of deployed in grid-scale, energy storage system to under \$300/kWh
- Transactive Energy - Enable buildings, large building loads, and EV charging systems to: 1) diagnose if they are functioning properly, 2) forecast their energy needs, 3) characterize their available flexibility, and 4) have embedded control and decision-making tools to provide capacity, energy and ancillary services

Security and Resilience



•High Level Outcomes

- Improved ability to identify, protect against, detect, respond to, and recover from threats, hazards, and incidents.
- Development of standards and guidelines, sharing of best practices, demonstration and validation of devices, advanced cyber-physical analytics and cognitive learning, methodologies and architectural frameworks, advanced substation and transformer technologies, and hardened communications

•Selected Major Technology Outcomes

- Hardened Transformers – Design and construct solid-state distribution (10-kV and 50-kV) and transmission (100-kV and 345-kV) transformers and deploy with greater resiliency characteristics
- Resilient Architectures - Adaptive and agile operating technologies framework that optimizes stability and efficiencies of operation while accommodating high penetration of distributed, renewables generation, smart loads, and energy storage



GMI as a 10-Year Journey

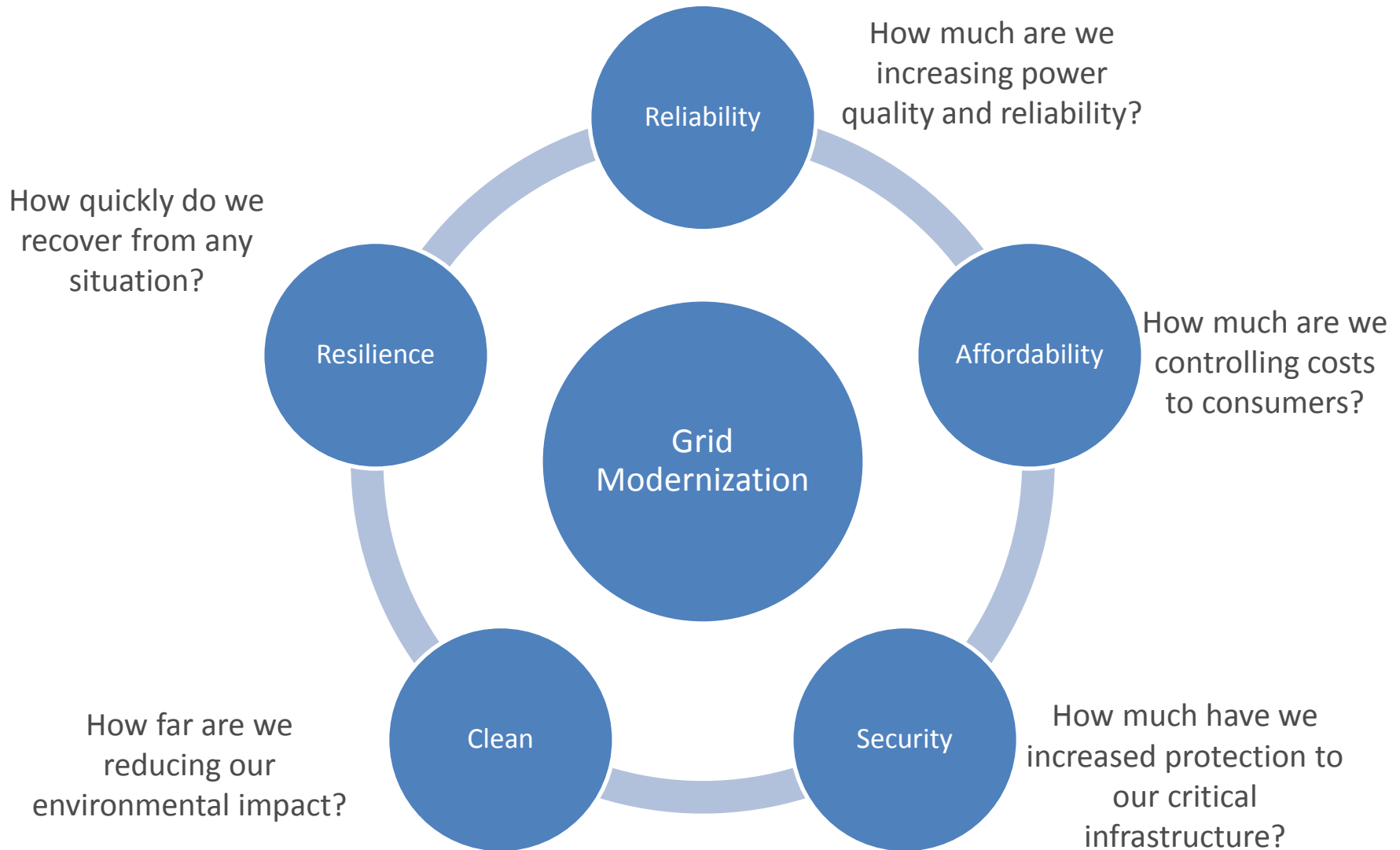
DOE delivers new capacity for modernization (analytical and valuation tools, architecture platforms, technical assistance, technologies)

Demonstrations and technology transferred to utilities, vendors, states, and consumers to modernize the grid and deliver outcomes

2015	→			2019	2020	→			2024
Regional outreach to hear needs and priorities Core R&D and technical assistance in six research streams	Request for Information to identify regional partners Initial tech transfer to industry	Funding Opportunity Announced for regional demos	Planning of regional demos Continue tech transfer to industry	Initiate regional demos Potential additional Funding Opportunity Announced Wrap up majority of core R&D and technical assistance	Implement regional demos Continue select areas of core R&D and technical assistance	Scale up regional demos Continue tech transfer to industry	Begin to deliver outcomes Continue select core R&D and technical assistance	Continue scale up regional demos Additional outcomes delivered	Demos complete with proofs of concept Concepts taken by industry and applied elsewhere Tech transfer complete



Measuring Successful Demonstrations





DOE Major Achievements—Demos

- **Major Achievement #1 – Lean Bulk Power Systems**
 - **Reliable:** Maintain reliable operations with a 10% reserve margin or lower
 - **Affordable:** New capability for grid operators to leverage and manage distribution-level grid services will require less generation reserve
 - **Secure:** Incorporate advance physical and cyber security measures for the integration of large numbers of devices
 - **Clean:** Systems include greater than 33% variable energy resources
 - **Resilient:** Improve recovery time for outages by a factor of two





DOE Major Achievements (con't)

- **Major Achievement #2 – Clean Distribution Systems**
 - **Reliable & Resilient:** Coordinated microgrid(s) control for resilience (e.g., 20% fewer outages, 50% shorter recovery time)
 - **Affordable:** Distributed, hierarchical control for clean energy and new customer-level innovation for asset utilization
 - **Secure:** Ensure high-level cybersecurity for all data-driven and operational models, improved physical security
 - **Clean:** Demonstrate reliable and affordable feeder operations with greater than 50% DER penetration





DOE Major Achievements (con't)

- **Major Achievement #3 – Grid Planning and Analytics**
 - **Reliable & Resilient:** Use coupled T&D grid planning models with 1000x speed-up to address specific grid issues
 - **Affordable:** Work with States to more rapidly evaluate new business models, impacts of policy decisions
 - **Secure:** Ensure high-level cybersecurity for all data-driven and operational models
 - **Clean:** Develop with stakeholders new data-driven approaches to DER valuation and market design





MYPP Status

- Technical sections completed
- Alignment with QER, QTR drafted
- Alignment with FY16 request completed
- Alignment with FY17 formulation in progress



Lab Call Status

- Development multi-year single lab call for grid related activities
- Issuance planned for Week of June 29th
- Suggest sub-group of EAC follow-up before next EAC meeting



Outreach Status

- Coordinated with other outreach with EPSA, EERE and OE, planning outreach meetings over next six months
- In conjunction with several meetings
 - Gridwise Alliance
 - Valuation



Stakeholder Engagement and Partnership

- Conduct regional dialogues to gather input on grid modernization needs and priorities
- Hold annual Grid Modernization Initiative progress summits
- Expand technical assistance to states, regions and tribes
- Develop partnerships to define and develop regional demonstrations
- Issue competitive research funding opportunities (e.g., FOAs and CRADAs)
- Engage in technology transfer from DOE programmatic advances
- Carry out ongoing peer review

